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# SCIENCE

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## ETHER-DRIFT EXPERIMENTS AT MOUNT WILSON[1]

AFTER the wave theory of light was established, it became necessary to assume the existence of an all-pervading medium in which the waves could be developed and transmitted; this hypothetical medium was called the "ether." It was endowed with such properties as were necessary for the explanation of observed phenomena. Several physicists sought to prove the existence of the ether by direct experiment. The most fundamental of such proposals was that of Professor A. A. Michelson, made in 1881, based upon the idea that the ether as a whole is at rest and that light waves are propagated in the free ether in any direction and always with the same velocity with respect to the ether. It was also assumed that the earth in its orbital motion around the sun passes freely through this ether as though the latter were absolutely stationary in space. The experiment proposed to detect a relative motion between the earth and the ether, and it is this relative motion which is often referred to as "ether-drift." The experiment is based upon the argument that the *apparent* velocity of light would vary according to whether the observer is carried by the earth in the line in which the light is traveling, or at right angles to this line. The velocity of light is 300,000 kilometers per second, while the velocity of the earth in its orbit is 1/10,000th part of this, 30 kilometers per second. If the earth's orbital velocity were directly effective, the two apparent velocities should differ by 30 kilometers per second or by one part in 10,000. However, there is no known method of measuring the velocities under such simple conditions. All methods require the ray of light to travel to a distant station and back again to the starting point, and a positive effect of the earth's motion on the ray going outward would be neutralized by a negative effect on the returning ray. But for a moving observer, it was shown that the neutralization would not be quite complete; the apparent velocity of the ray going and coming in the line of the earth's motion would differ from the apparent velocity of the ray going and coming at right angles, in the ratio of the square of the velocity of the earth to the velocity of light, that is, by an amount equal to one part in $(10,000)^2$ or to one part in 100,000,000.

[1] Read before the National Academy of Sciences, Washington, April 28, 1925.

A remarkable instrument known as the "interferometer," which had been invented by Professor Michelson, is capable of detecting a change in the velocity of light of the small amount involved in ether drift. In this experiment a beam of light is literally split in two by a thin film of silver, on what is called the "half-silvered mirror"; the coating of silver is thin enough to allow about half of the light to pass straight through, while the other half is reflected in the usual manner. These two beams of light may thus be made to travel paths at right angles to each other. At the end of the desired path each beam is reflected back upon itself and the two come together where they first separated. If the two paths are optically equal, that is, if there are exactly the same number of wave-lengths of light in each, the reunited portions will blend with the waves in concordance. If, however, one path is a half-wave longer than the other, the waves will come together in "opposite phase," the crest of one coinciding with the trough of the other. These and other phase relations between the two rays produce effects called "interference fringes," observation of which enables one to detect slight changes in the velocity of light in the two paths.

In the year 1887, in Cleveland, Professor Michelson, then professor of physics at Case School of Applied Science, in collaboration with Professor Edward W. Morley, of Western Reserve University, made certain important developments of method and apparatus and used the interferometer in an effort to determine whether the motion of the earth through space produces the effect upon the velocity of light predicted by theory. Unfortunately we do not know in what absolute direction the earth is going through space and so it is not possible to place the interferometer certainly in this direction. Therefore, the whole apparatus is mounted on a base which floats on mercury so that it can be turned to all azimuths of the horizontal plane of observation in the effort to find the direction of the presumed ether drift. The rotation of the earth on its axis causes the plane of the interferometer to move as though it were on the surface of a cone whose axis coincides with that of the earth and thus to take many different space orientations. It is only that component of the actual drift which lies in the horizontal plane of the interferometer at the moment of observation which can be observed. Therefore the *apparent* azimuth and magnitude of the drift should change with the time of observation. A drift perpendicular to the plane of the interferometer will produce no effect whatever; it is quite possible that this condition may occur at certain times of the year.

It is not possible at this time to explain the details of the principles involved. The observations are made by looking through a telescope at the system of interference fringes formed by the two beams of light. As the interferometer is rotated on its axis, an ether drift would cause the whole system of fringes to oscillate, moving first to one side and then to the other, this effect being periodic in each *half* revolution of the interferometer about its vertical axis. For a relative motion of the earth and the ether equal to the orbital velocity of the earth, that is 30 km/sec, the displacement in the original Michelson-Morley experiment would have been 4/10th of a fringe.

In November, 1887, Michelson and Morley announced the conclusions drawn from their observations made in July of that year as follows: "Considering the motion of the earth in its orbit only . . . the observations show that the relative motion of the earth and the ether is probably less than one sixth of the earth's orbital velocity and certainly less than one fourth." (That is, it is less than 7½ kilometers per second.) This result was considered by many as a null result, often called a negative result, and by some was thought to throw grave doubts upon the validity of the hypothesis of the luminiferous ether. There is a significant "Supplement" to this report which begins with the following sentence: "But it is not impossible that at even moderate distances above the level of the sea, at the top of an isolated mountain peak, for instance, the relative motion might be perceptible in an apparatus like that used in these experiments."[2]

At the International Congress of Physics, held in Paris in 1900, Lord Kelvin gave an address in which he considered theories of the ether. He remarked that "the only cloud in the clear sky of the theory was the null result of the Michelson-Morley experiment." Professor Morley and the writer were present, and in conversation with Lord Kelvin he expressed the conviction that the experiment should be repeated with a more sensitive apparatus. The writer in collaboration with Professor Morley constructed an interferometer about four times as sensitive as the one used in the first experiment, having a light path of 224 feet, equal to about 150,000,000 wave lengths. In this instrument a relative velocity of the earth and ether equal to the earth's orbital velocity would be indicated by a displacement of the interference fringes equal to 1.5 fringes. This is the size of the instrument which has been used ever since. The optical parts were all new and nothing was used from the original apparatus excepting the mercury tank and its wooden float.

Such an instrument with a base made of planks

[2] Michelson and Morley: "Relative motion of the earth and the luminiferous ether," *Am. Jl. of Sci.*, 34, 333 (1887); *Phil. Mag.*, 24, 449 (1887); *Jl. de Phys.*, 7, 444 (1888).

of wood was used in 1902 and 1903, but the changes in the wooden frame due to the variations in humidity and temperature made accurate observations impossible. A new supporting frame was designed by Professor F. H. Neff, of the department of civil engineering of Case School of Applied Science, the purpose being to secure both symmetry and rigidity. This frame, or base, was constructed of structural steel, and was erected in a basement room in the Physical Laboratory of Case School of Applied Science in Cleveland, and observations were made in 1904 and 1905. The results of these observations were published in *The Philosophical Magazine* for May, 1905. They were stated as follows: "We may therefore declare that the experiment shows that if the ether near the apparatus did not move with it; the difference in velocity was less than 3.5 kilometers per second unless the effect on the materials annulled the effect sought. Some have thought that this experiment only proves that the ether in a certain basement room is carried along with it. We desire therefore to place the apparatus on a hill to see if an effect can be there detected."[3]

It was at this time that Einstein became interested; and later in the year, 1905, he published a paper on "The electrodynamics of moving bodies."[4] This paper was the first of a long series of papers and treatises by Einstein and others which has developed into the present theory of relativity. In this first paper, Einstein states the principle of the constancy of the velocity of light, tending to show that for an observer on the moving earth, the measured velocity of light would be constant, regardless of the direction or amount of the earth's motion. The whole theory was related to physical phenomena, largely on the assumption that the ether-drift experiments had given a definite and exact null result. This interpretation of the experiment was not acceptable to the writer, and further observations were undertaken to determine this particular question.

In the autumn of 1905, Morley and Miller removed the interferometer from the laboratory basement to a site on Euclid Heights, Cleveland, at an altitude of about 300 feet above Lake Erie, and free from obstruction of buildings. Five sets of observations were made in 1905–1906, which give a definite positive effect of about 1/10 of the then "expected" drift. There was a suspicion that this might be due to a temperature effect, though there was no direct evidence of this. A plan was made for putting this surmise to the test after a summer's vacation. We had erected the interferometer on land owned by a friend; during our vacation absence, the land was sold and the new owner ordered the immediate removal of the interferometer.

Professor Morley retired from active work in 1906 and it devolved upon the present writer to continue the experiments. It seemed desirable that further observations should be carried out at a much higher altitude, but numerous causes prevented the resumption of observations. The publication of reports on the solar eclipse of 1919, which were interpreted as confirming the theory of relativity, revived the interest in the ether-drift experiments. A generous friend provided ample funds to cover the considerable expense involved. The site of the Mount Wilson Observatory near Pasadena, California, at an elevation of about 6,000 feet, seemed to be a suitable place for further trials. Through the kindness of President Merriam, of the Carnegie Institution at Washington, and of Directors Hale and Adams, the experiments were resumed by the writer in March and April, 1921, at the Mount Wilson Observatory. The apparatus was substantially the same as that used by Morley and Miller in 1904, 1905 and 1906. Observations were also made in the latter part of the year 1921 and again in 1924 and 1925.

At the Mount Wilson station, about 5,000 single measures of the ether-drift have been made at various times of the day and night. These have been reduced in 204 different sets, each set consisting of observations made within one hour's time. The observations correspond to four different epochs of the year, as follows: I. April 15, 1921, 117 sets of observations; II. December 8, 1921, 42 sets; September 5, 1924, 10 sets; and April 1, 1925, 35 sets.

The very first observations made in March, 1921, gave a positive effect such as would be produced by a real ether drift, corresponding to a relative motion of the earth and ether of about ten kilometers per second. But before announcing such a result it seemed necessary to study every possible cause which might produce a displacement of fringes similar to that caused by the ether drift. The causes suggested were magnetic deformation of the steel frame of the interferometer and the effects of radiant heat. In order to eliminate the effects of radiant heat the metal parts of the interferometer were completly covered by cork about one inch thick. Fifty sets of observations were made under these conditions, showing the periodic displacement of the fringes due to the drift agreeing with the first observations.[5]

[3] Morley and Miller: "An experiment to detect the Fitz-Gerald-Lorentz effect," *Phil. Mag.*, 9, 680 (1905); Proc. Am. Acad. Arts and Sci., 41, 321 (1905); "On the theory of experiments to detect aberrations of the second degree," *Phil. Mag.*, 9, 669 (1905).

[4] Einstein: "Zur electrodynamik bewegter Körper, *Ann. der Physik*, 17, 891 (1905).

[5] Miller: "Ether-drift experiments at Mount Wilson Observatory," *Phys. Rev.*, 19, 407 (1922); SCIENCE, 55, 496 (1922).

In the summer of 1921 the steel frame of the interferometer was dismounted and a base of one piece of concrete reinforced with brass was cast in place of aluminum or brass, thus the entire apparatus was on the mercury float. All the metal parts were made free from magnetic effects and the possible effects due to heat were much reduced. In December, 1921, 42 sets of observations were made with the non-magnetic interferometer. These show a positive effect as of an ether drift which is entirely consistent with the observations of April, 1921. Many variations of incidental conditions were tried at this epoch. Observations were made with rotations of the interferometer clockwise and counter clockwise, with a rapid rotation and a very slow rotation, with the interferometer extremely out of level, due to the loading of the float on one side. Many variations of procedure in observing and recording were tried. The results of the observations were not affected by any of these changes.

The entire apparatus was returned to the laboratory in Cleveland. During the years 1922 and 1923, many trials were made under various conditions which could be controlled and with many modifications of the arrangements of parts in the apparatus. An arrangement of prisms and mirrors was made so that the source of light could be placed outside of the observing room, and a further complication of mirrors was tried for observing the fringes from a stationary telescope. Methods of photographic registration by means of a motion picture camera were tried. Various sources of light were employed, including sunlight and the electric arc. Finally an arrangement was perfected for making observations with an astronomical telescope having an objective of five inches aperture and a magnification of fifty diameters. The source of light adopted was a large acetylene lamp of the kind commonly used for automobile headlights. An extended series of experiments was made to determine the influence of inequality of temperature and of radiant heat, and various insulating covers were provided for the base of the interferometer, and for the light path. These experiments proved that under the conditions of actual observation the periodic displacement could not possibly be produced by temperature effects. An extended investigation in the laboratory demonstrated that the full-period effect mentioned in the preliminary report on the Mount Wilson observations is a necessary geometrical result of the adjustment of mirrors when fringes of finite width are used and that the effect vanishes only for fringes of infinite width, as is presumed in the simple theory of the experiment.

In July, 1924, the interferometer was taken again to Mount Wilson and mounted on a new site where the temperature conditions were more favorable than those of 1921. The interferometer house was also mounted with a different orientation. Again the observations showed a definite positive effect corresponding to the observations previously made at Mount Wilson. The observations on Mount Wilson were resumed in March, 1925, and continued until about the middle of April, during which time 1,600 measures of the drift in 35 sets were made. Again many variations in detail of arrangement of parts and in methods of observing were made without in any way altering the result. Throughout the latter epoch of observations, the conditions were exceptionally good. Some of the time there was a fog which rendered the temperature very uniform. Four precision thermometers were hung on the outside of the house. On several occasions the extreme variation of temperature was not more than 0.1 degree and usually it was less than 0.4 degree. Such variations did not at all affect the periodic displacement of the interference fringes. The observations of April, 1925, give results almost identical with those of April, 1921, notwithstanding that the interferometer had been rebuilt and that a different system of illumination and different methods of observation were employed and that it was mounted on a new site in a house differently oriented.

The interferometer readings, being plotted, give directly by harmonic analysis (carried out with the mechanical harmonic analyzer) the azimuth and magnitude of the ether drift. There are no corrections of any kind to be applied to the observed values. In the work so far, every reading of the drift made at Mount Wilson has been included at its full value. No observation has been omitted because it seemed to be poor, and no "weights" have been applied to reduce the influence on the result, since no assumption has been made as to the expected result. It may be added that while the readings are being made, neither the observer nor the recorder can form the slightest idea as to whether any periodicity is present, much less as to the direction or amount of such periodicity.

The test of these observations is whether they lead to a rational and wholly consistent indication of a constant motion of the solar system in space, combined with the orbital motion of the earth and the daily rotation on its axis. There is a specific relation for a given latitude between the observed azimuth of drift and the sidereal time of observations. Observations at different sidereal times should show different azimuths and all observations at the same sidereal time should show the same azimuth for a given epoch. A preliminary graphical solution of the observations indicates that these conditions are fulfilled.

It need hardly be said that the determination of the absolute motion of the solar system from such interferometer observations is one of great complex-

ity. Professor J. J. Nassau, of the department of mathematics and astronomy of Case School of Applied Science, and Dr. G. Strömberg, of the staff of the Mount Wilson Observatory, have given very great assistance in the mathematical analysis, and have developed solutions of various parts of the problem, and also a complete least-squares solution of the general problem. A definitive numerical calculation will require several months of continuous work and is now in progress.

The ether-drift experiments at Mount Wilson during the last four years, 1921 to 1925, lead to the conclusion that there is a positive displacement of the interference fringes, such as would be produced by a relative motion of the earth and the ether at this observatory, of approximately ten kilometers per second, being about one third of the orbital velocity of the earth. By comparison with the earlier Cleveland observations, this suggests a partial drag of the ether by the earth, which decreases with altitude. It is believed that a reconsideration of the Cleveland observations, from this point of view, will show that they are in accordance with this presumption, and will lead to the conclusion that the Michelson-Morley experiment does not and probably never has given a true zero result. A complete calculation of experiments, to be made in the immediate future, should give definite indications regarding the absolute motion of the solar system in space.

DAYTON C. MILLER

CASE SCHOOL OF APPLIED SCIENCE

## RISKS INCURRED IN THE INTRODUCTION OF ALIEN GAME BIRDS

WITH the decrease in the supply of game animals which has inevitably accompanied the close settling of our country by Europeans, it has commonly occurred to those interested to remedy the situation by importing and planting non-native species which it is thought might be more prolific or hardier than the native species. This idea at first thought is appealing, and it has seemed so reasonable to many game administrators that it has been tried over and over again both in our own state (I am writing from California) and in other states, at great public expense. Experiments of this sort within the state of California alone have entailed the expenditure of upwards of fifty thousand dollars, as shown by the printed reports of our California Fish and Game Commission. But, not one non-native game species has become established here to a degree of success warranting the declaration of an "open season" upon it.

It has just been announced through the public press that our state fish and game commission, apparently forgetting all these past and unsuccessful experiments, has again under serious consideration a plan for raising in captivity and liberating certain non-native game birds; and the kind specifically mentioned is the Hungarian partridge. This announcement must bring dismay to every student of nature whose concern (as is my own) extends to include the welfare and usefulness to man of California's wild life generally and is not restricted to objects of sport alone.

In the first place, it is believed by some thinking naturalists that the chances are decidedly against the success of this project—success as bringing the beneficent results expected of it by the gunner. To repeat, such experiments have already been tried,[1] and these have involved no less than twelve non-native game species and an aggregate of at least 13,000 individual birds, by record, liberated. No success has been achieved. Are chances of success now, with further depletion of natural food and cover, any better than before?

Howsoever, *if* the introduction now proposed *should* prove successful from the sportsman's standpoint and, say, the Hungarian partridge become fully established, what would be the possible, even probable, results? One result, about which there is no question whatsoever in my own mind, would be the crowding out, the supplanting, in partial measure if not altogether, of our native California quail.

An axiom which I think all close students of natural history would accept without reservation is as follows: No two species of identical or even closely similar biological predilections can long occupy the same niche or ecologic space at the same time. If the same food supply, in kind and amount, if the same type of shelter for roosting or resting, or if the same sort of breeding places be resorted to by two species, there will be inevitable conflict. One or the other species will give way, because bound to be at less advantage in some respect as to structural equipment or instinctive manner of reacting to the conditions about it. The Hungarian partridge and the California quail belong to two genera of gallinaceous birds within the same family. While there are undoubtedly some differences between these two birds in their ecological requirements, the general similarities are exceedingly close. More or less keen competition would be bound to operate sooner or later to the disadvantage of one of them. I, for one, hereby protest against any act that will likely jeopardize the existence of our native Califor-

[1] See Grinnell, Bryant and Storer, "Game Birds of California," 1918, pp. 29 to 44.

nia quail, than which there is no finer game species in the world, according to the testimony of experienced sportsmen themselves. A species once exterminated is beyond recall.

As bearing further upon this question of the dangers of competitive replacement, I would point out what seems to be a general natural law, which may be stated as follows: When a species native to a large area is successfully introduced into a new small area the related species which is native in this area and with which the former comes into competition is soon supplanted. There are scores of cases supporting this law—among European species introduced into Australia and New Zealand, Australian species introduced into New Zealand, and European (that is, Eurasian) species introduced into North America. It looks as though the environment of large compass, where the long-time inhabitants have been subjected to the widest range in the rigors of existence, has developed species of the greatest hardihood, and particularly of the greatest degree of aggressiveness. The European house sparrow, the European starling and the Chinese mynah have been spreading at an amazing rate in North America, with testimony overwhelmingly to the effect that American species of wild birds are giving way before them. The Hungarian partridge, if, as our state fish and game commission expects, it be once established in California, would, according to this apparent law, eventually dominate our territory as against the less aggressive native valley quail and mountain quail. These would be crowded to the wall; at worst, become extinct.

Do sportsmen themselves, let alone nature-lovers and scientific students of wild life, invite such a calamity? It is perfectly clear to me that this one threatening peril, that of displacement of our wonderfully attractive native quail and grouse, should decide against the carrying out of any plan to bring in and plant any alien game bird.

Besides, there are other dangers which, in the larger interests, even essentially economic interests, should not be overlooked in weighing the wisdom of the proposed introduction. There is the danger that some disease or parasite inherent in a species of foreign origin would be brought in and transmitted to native birds of various sorts or even to domestic birds. These native or domestic species would likely enjoy no such relative immunity to a disease new to them as would the species in which the said disease is, one may say, normal. Instances of this very sort have occurred in other countries. Is it justifiable to run even the faintest chance of receiving into our agricultural districts some new poultry disease?

All students of nature, sportsmen themselves, will grant that in final analysis *the* factor which is operating to reduce our supply of native game, aside from concentrated shooting in thickly settled districts, is that of constantly diminishing subsistence. This factor, of diminishing subsistence, becomes critically effective at the seasons of the year when suitable food is scarcest and when shelter (safety from enemies when resting or roosting, and safe breeding places) is most necessary. Close settlement and the clearing of the lower country, the using up of the surface water by taking it out of the stream courses up in the hills and by underground pumping (which results in the disappearance of brushy growths along the lower stream courses), incessant and close grazing and browsing of the higher country by sheep and cattle, are some of the human-wrought processes continually modifying this factor of subsistence of not only our game birds but of most other native and desirable forms of wild life. The rule is manifest, that the total permanent population of a given species, its breeding stock, can not be above the number that will find subsistence at the severest period of the year. And furthermore, to bring in the main theme of the present plea, if a competing species be introduced, the latter will become established "successfully" only in direct proportion as it appropriates food and shelter upon which the population of the native species of similar ecologic bearing depends. Reduction, and possibly ultimate disappearance, of the native bird will follow as night follows day.

It has been claimed by those who advocate the introduction of non-native game birds that it is much the more likely that Asiatic pheasants and European partridges would thrive on reclaimed, closely settled lowlands, where the native quail have already disappeared from various human-wrought causes. This *might* prove true; but there is no guaranteeing that those alien species would, if successful to the desired extent, then "stay put." There would be no barrier, certainly, to prevent their going beyond the cultivated districts, and then their inherent aggressiveness would lead them into direct competition on the wild territory with the native species.

It is not unfair, and is certainly germane to the question, if I remind my readers of the tenet that game birds at large do not belong exclusively to those who go out to shoot them. Rapidly increasing numbers of people are finding recreation in the outdoor study of wild life, in observing living animals, in trying to understand the intricate problems of their existence. Mental as well as physical recreation comes with this sort of use of our wild life assets. More and more, the field glass and the camera are taking the place of the shotgun and the rifle. The newer generation by hundreds of thousands is turning to nature-out-of-doors, for recreation, in-

struction and pleasure through such agencies as the Boy Scouts, Girl Scouts, Camp Fire Girls, summer camps and national parks. These people are interested in all forms of wild life—including the native game species. While I, myself, take out a hunting license, and have within a year shot quail with exercise of the sportsman's instincts, I am ready to grant that other people have claims on our game for reasons not involving the use of the shotgun. I am willing to grant, not total protection of truly game species of birds, but that the interests of *all* concerned should be heeded in the administration of our natural resources. Far and away the greatest value—recreationally, educationally and scientifically—inheres in our *native* complement of wild animal life.

The common problem of the sportsman and nature student alike is that of *maintaining* our native fauna, as nearly as is possible consistently with the inevitable disturbance due to settlement of our country. The practicable way of saving both our game and our non-game birds in largest measure is to provide refuges for them; to recognize the necessity of leaving here and there strips of wholly natural cover for them, especially by eliminating close grazing and browsing from such tracts; to insure game law enactment and enforcement to a point where the annual draft by hunters will not exceed the annual increase. And a final consideration must be heeded, namely, the danger in permitting the implantation of alien kinds: *We do not want* anything "bigger and finer" than, for example, our own California and mountain quails!

The California Fish and Game Commission has, it is true, done splendid work, upon a sound biological principle, in establishing game refuges here and there in suitable places throughout the state. But in any attempt to plant alien kinds of game within our borders I believe the commission to be wrong. One aim in my present endeavor to give clearly the reasons against such attempt is so that in future years it can not be said that some responsible student of natural history, who should have recognized the dangers threatened, did not speak in time.

JOSEPH GRINNELL
MUSEUM OF VERTEBRATE ZOOLOGY,
BERKELEY, CALIFORNIA

## SCIENTIFIC EVENTS

### A NATIONAL PARK IN THE BELGIAN CONGO

HIS EXCELLENCY BARON DE CARTIER DE MARCHIENNE, Belgian Ambassador, wrote on April 23, 1925, to Dr. John C. Merriam, president of the Carnegie Institution and vice-president of the National Academy of Sciences, as follows:

Ambassade de Belgique,
1780 Mass. Ave.,
Washington, D. C.

April 23, 1925

My dear Dr. Merriam:

In accordance with our conversation when I last had the pleasure of seeing you, I am now sending you some additional details in regard to the "Albert National Park" ("Parc National Albert"), which has been established in the Belgian Congo for the protection and scientific study of the native flora and fauna.

The advance of civilization into Central Africa has brought with it its inevitably attendant menace to primitive forms of wild life. This National Park has therefore been laid off, under the auspices of His Majesty King Albert, as a sanctuary where both animals and plants and natural scenery may be preserved and where scientists from all over the world may eventually come to study the flora and fauna of Africa in their original and natural surroundings.

During the past few years there has been an ever-increasing influx of big-game hunters and natural scientists into the Belgian Colony which is the last refuge of many rare species of African fauna. The Belgian Government has recognized the necessity of permitting a certain number of such rare animals to be taken for scientific purposes, but has consistently endeavored to preserve these rare species and also to prevent the wanton destruction of other less rare, but harmless, animals, whose slaughter serves no useful purpose.

In these circumstances the Belgian Colonial Authorities have found it necessary to restrict not only private hunting expeditions but also similar expeditions contemplated by many of the most distinguished Museums of Natural History and other scientific bodies.

Among the rare animals which are in danger of extinction is the Gorilla—an animal of extreme interest to scientists. The Belgian Government has, in the past, felt it its duty to permit a few specimens to be killed or captured for strictly scientific purposes, but the time has come when, in the interests of humanity, as well as in the interests of Science itself, steps must be taken to preserve the remaining gorillas from extermination.

A short time ago King Albert's attention was drawn to the possibility of establishing a "sanctuary" for the wild flora and fauna in the Kivu District which lies in the northeastern section of the Belgian Congo.

In this region, besides many other rare wild animals, are still to be found a number of gorillas, perhaps 100 or 200, and it is thought that, if properly protected, they may not only be preserved, but may become so accustomed to man that they may be studied in their native surroundings in a way that would rapidly produce most interesting scientific results.

In pursuance of this idea, His Majesty the King signed a Royal Decree on March 2nd, 1925, defining the limits of the "Parc National Albert," setting forth its pur-

poses and providing severe penalties for violation of the regulations.

The reservation embraces the three volcanoes, Mt. Mikeno, Mt. Karissimbi and Mt. Vissoke. Within this district it is forbidden to kill or capture any kind of wild animal—even those which are dangerous—except in case of legitimate self-defense or by government order. It is also forbidden to destroy eggs or nests of wild birds, or to cut down, up-root or carry away any native tree or plant. Provision is also made for proper supervision and policing of the reserve.

The district above outlined is the region inhabited by rare animals, notably the gorillas, and comprises about 92 square miles. It is intended to surround this special reserve by a second reserve (under less severe restrictions) covering approximately eight hundred square miles.

In this Parc National Albert it is planned to erect a laboratory for biological studies where scientists from all parts of the world may eventually come and study the flora and fauna of the Belgian Congo as well as the geological and meterological conditions.

In inaugurating this new experiment—the first of its kind in Central Africa—the King and His officials have studied the great American reservations and national parks and have sought the advice of eminent American scientists.

In order that the best results may be achieved it is hoped that this humanitarian and scientific project may receive the sympathetic cooperation of the members of the National Academy of Sciences, and the benefit of their experience and wise counsel.

With deep appreciation of the interest which you have been kind enough to take in the matter and with high regard, I remain, my dear Dr. Merriam,

Yours very sincerely,

(Signed) E. CARTIER.

This letter was presented at the meeting of the National Academy of Sciences, held in Washington on April 29, and the following resolution was passed by the academy:

The National Academy of Sciences desires to express its gratification at the action of His Majesty the King of the Belgians in the establishment of the *Albert National Park* for the effective preservation of the Gorilla and other animals, together with the protection of the flora of the region; and assures His Majesty of its deep interest and its disposition to cooperate in the realization of the benefits to science and mankind arising from this wise and generous action.

Following action by the academy, the president has appointed a committee consisting of Robert M. Yerkes, *Chairman,* Clark Wissler, E. G. Conklin and F. M. Chapman.

## THE SOCIETY FOR CULTURAL RELATIONS WITH FOREIGN COUNTRIES OF THE SOVIET UNION

IN a circular sent out a few months ago, the Russian Information Bureau in Washington called attention to the organization in Moscow of the Joint Information Bureau for the purpose of establishing closer relations between cultural and scientific bodies in the Soviet Union and those of other countries.

At a recent meeting (April 5, 1925, in Moscow) of representatives of the principal cultural and scientific societies of the Soviet Union this project assumed more definite form and a broader scope. The Joint Information Bureau was replaced by the more comprehensively named Society for Cultural Relations with Foreign Countries, which is designed to embrace the cultural societies of the whole Union.

The following officers were elected: *President,* Madame O. D. Kameneva; *Vice-president,* Mr. N. I. Loboda; *Corresponding Secretary,* Mr. D. P. Bukhartsev.

The society has organized the following departments:

(1) Contact Bureau, to establish contacts with foreign societies for the purpose of exchanging information, views, reports, etc., of a cultural and scientific character. This bureau will also engage in answering various inquiries coming from abroad, in collecting general information about cultural conditions in foreign countries, in the exchange of professors and students between the Soviet Union and other countries, in gathering data concerning international and national congresses, conferences and expositions abroad and in the Soviet Union, etc.

(2) The Book Exchange Bureau, which will conduct all exchanges of general and scientific books between the Soviet Union and foreign countries.

(3) Press Bureau, which will look after the compilation and publication of a bulletin of cultural and scientific life in the Soviet Union. This section will also supply foreign countries with articles and notes of cultural interest on the various phases of Soviet life, and it will furnish institutions and organizations of the Soviet Union with clippings from general and technical foreign publications and *vice versa.*

(4) Service Bureau for Foreign Visitors, which will assist foreigners visiting the Soviet Union for the purpose of acquainting themselves with the cultural life and customs of the Soviet Union. This division will likewise extend its services to arrange tours for foreign professors, scientists, etc., visiting the Soviet Union, and reciprocal tours in foreign countries, for study and research, by citizens of the Soviet Union.

(5) Russ-Photo Bureau, which will supply pictorial material covering life in the Soviet Union to

the foreign press, and foreign illustrations to the Soviet press.

Interested institutions, organizations and individuals may communicate with the Russian Information Bureau, 2819 Connecticut Avenue, Washington, D. C., which has undertaken to represent the reorganized body in the United States, or directly with the Society for Cultural Relations, Moscow, Sverdlov Place, Second Soviet House, Apartment A.

## THE DANIEL GUGGENHEIM SCHOOL OF AERONAUTICS

MR. DANIEL GUGGENHEIM has given $500,000 to New York University to establish a School of Aeronautics in connection with the College of Engineering. In his letter to Chancellor Elmer Ellsworth Brown, Mr. Guggenheim says:

For some time I have been impressed with the need for placing aeronautics on the same educational plane that other branches of engineering enjoy. It has seemed to me that aviation is capable of rendering such service to the nation's business and economic welfare as well as to its defense that our universities should concern themselves with the education of highly-trained engineers capable of building better and safer commercial aircraft, and industrial engineers capable of making the operation of aircraft as a business proposition comparable to the operation of railroads. In this way we shall give America the place in the air to which her inventive genius entitles her.

The great future of aviation and aeronautics is in the promotion of the arts of peace rather than war.

Already, we have the air mail, the use of airplanes in surveying, in photography, in prevention of forest fires and in fishery to indicate to us how great are the possibilities for extending the usefulness of aviation outside of the wartime employment of airplanes, upon which the attention of aeronautical engineers was first concentrated.

If we are quickly to realize for humanity and our country the ultimate possibilities of navigation of the air, we must have planes that are fool-proof, stable, capable of recovering from abnormal positions, able to land in easily available places and with the necessary speed and carrying capacity. Even the layman can understand that these things and others that engineers are trying to accomplish require specialized study with special equipment, and I am informed that no adequate opportunity for such study and experimentation exists in this country.

My family has long been identified with exploration beneath the earth. We have tried to assist in developments which would make mining more safe as well as more profitable and therefore of the greatest economic value. I have learned through my son, Harry F. Guggenheim, who was one of the first civilians to enter aviation and was a naval aviator overseas during the World War, of the plans of New York University to establish a School of Aeronautics in its College of Engineering.

I take pleasure in making possible the accomplishment of that desire. I am handing you herewith my check for $500,000 and a deed of trust relating to the use of that sum for the foundation of a School of Aeronautics in New York University.

I understand that approximately $225,000 of the fund will be required and is to be used for the purpose of building and equipping a building, a wind tunnel, propeller laboratory, sand-testing laboratory, model shop full-flight laboratory, power plant laboratory and classrooms. I understand that the balance of the fund will be required to provide for the salaries of a professor, an assistant professor and instructor in aeronautics and two research assistants, and also for the maintenance of the building and equipment.

The new field of employment and endeavor that aeronautical engineering will open to young men is one of the many reasons why this gift is made. Here is an uncrowded professioon, offering opportunities unmatched in possibilities.

I have created this trust with full confidence that it will be ably and wisely administered by your great institution and that it will promote the welfare of our country in time of peace and the safety of our country against aggression in time of war.

## NATIONAL RESEARCH FELLOWSHIPS IN THE BIOLOGICAL SCIENCES

THE Board of National Research Fellowships in the Biological Sciences met on April 30th and made the following appointments and reappointments for the year 1925–26:

*Reappointments*

Edward F. Adolph, zoology.
E. G. Anderson, botany.
L. R. Cleveland, zoology.
Herbert Friedmann, zoology.
M. J. Herskovits, anthropology.
Marie A. Hinrichs, zoology.
N. D. Hirsch, psychology.
J. Hobart Hoskins, botany.
C. R. Hursh, botany.
H. S. Liddell, zoology.
W. E. Loomis, botany.
William Seifriz, botany.
A. M. Showalter, botany.
Lee E. Travis, psychology.
F. B. Wann, botany.

*New Appointments*

Chester I. Bliss, zoology.
Hugh C. Blodgett, psychology.
J. N. Couch, botany.
H. W. Feldman, zoology.
A. M. Holmquist, zoology.
Karl E. Mason, zoology.
Margaret Mead, anthropology.
M. F. Metfessel, psychology.
Frank A. Pattie, Jr., psychology.

P. K. Roest, anthropology.
L. J. Stadler, botany.
L. E. Wehmeyer, botany.
Conway Zirkle, botany.

In addition to the above, Messrs. Leigh Hoadley and Carney Landis (reappointments) and Messrs. R. A. Brink, Laurence Irving and Miss Mildred Trotter (new appointments) were recommended to the International Education Board for Fellowships for study abroad. These recommendations have been approved.

Among the fellows for the year 1925–26 are also to be included Drs. T. N. Jenkins and Helen Redfield, whose appointments began late in the year and who were not yet ready for consideration for reappointment.

A second meeting of the board to consider further applications for the year 1925–26 will, in all probability, be held the first week in September. Applications to be presented at this meeting should be filed by August 1. Information and application forms may be obtained from the Secretary, Board of National Research Fellowships in the Biological Sciences, National Research Council, Washington, D. C.

FRANK R. LILLIE, *Chairman*,
Board of National Research Fellowships
in the Biological Sciences

## SCIENTIFIC NOTES AND NEWS

MISS ANNIE J. CANNON, of the Harvard College Observatory, received the degree of doctor of science from Oxford University on June 16.

DR. MICHAEL PUPIN, professor of electro-mechanics in Columbia University, president of the American Association for the Advancement of Science, was awarded the honorary degree of doctor of science by Union College on June 8.

HONORARY degrees of doctor of engineering were granted by the Case School of Applied Science on May 28 to Professor Michael I. Pupin, of Columbia University; to Professor C. A. Adams, of Harvard University; to Worcester R. Warner, of the firm of Warner and Swasey, and to Professor C. F. Mabery, professor emeritus of chemistry at Case School of Applied Science.

DR. EDGAR F. SMITH, former provost of the University of Pennsylvania and professor of chemistry, has had conferred upon him by Dickinson College the honorary degree of doctor of laws.

HONORARY degrees conferred by New York University at its ninety-third commencement on June 10 include that of doctor of laws on Dr. John C. Merriam, president of the Carnegie Institution, and that of doctor of science on Dr. A. R. Dochez, of the College of Physicians and Surgeons of Columbia University.

MME. CURIE, on June 7, laid the cornerstone of a radium institute and hospital in Warsaw to be named in her honor.

DR. SIMON FLEXNER, director of the Rockefeller Institute for Medical Research, has been appointed an honorary member of the Argentine Biological Society, Buenos Aires.

DR. RAYMOND PEARL, director of the Institute for Biological Research of the Johns Hopkins University, has been elected an honorary fellow of the Royal Statistical Society.

DR. HENRY M. HURD celebrated his eighty-second birthday on May 3. Dr. Hurd was the first president of the Johns Hopkins Hospital and is now emeritus professor of psychiatry at the Johns Hopkins University.

PROFESSOR WILLIAM MORRIS DAVIS, Sturgis Hooper professor of geology, emeritus, has been appointed an exchange professor from Harvard University for the year 1925–26 under the interchange agreement between Harvard University and the western colleges. Professor Davis's term of service will fall in the first half-year.

PROFESSOR RICHARD T. HEWLETT will retire from the university chair of bacteriology at Kings College, University of London, on August 1, in consequence of the closing of the department of bacteriology and public health at the college. The title of emeritus professor of bacteriology has been conferred upon Dr. Hewlett.

PROFESSOR RICH DEAN WHITNEY, head of the department of electrical engineering at Syracuse University, has resigned to engage in commercial work.

ALBERT H. KAMPE, who graduated in engineering from George Washington University in 1924, has been appointed observer on the staff of the department of terrestrial magnetism of the Carnegie Institution of Washington.

RALPH WILLIAM GAWTHROP, assistant professor of chemistry and physics at Ursinus College, has resigned to accept a position in the research laboratories of the E. I. DuPont de Nemours Co., at Wilmington, Delaware.

PROFESSOR CARL C. FORSAITH, of the department of wood technology of the New York State College of Forestry at Syracuse University, has accepted an offer from the English government through the Imperial Forestry Institute at the University of Oxford to organize a department of wood technology at the university.

THE Kansas Entomological Society was formed recently at a meeting of entomologists at the Kansas

State Agricultural College. Dr. Paul B. Lawson, Lawrence, was elected president of the society and Professor J. W. McColloch, Manhattan, was named secretary. The society will hold its meetings annually in connection with those of the Kansas Academy of Science.

PROFESSOR L. J. HENDERSON, of the Harvard University Medical School, gave a course of three lectures on "Blood and circulation from the standpoint of physical chemistry," on June 10, 11 and 12, at the University of London.

DR. GEZA DOBY, professor of biochemistry at the University of Budapest, Hungary, gave an address at Iowa State College on April 29 under the auspices of Sigma Xi. His subject was "The biological significance of enzymes."

PROFESSOR G. W. STEWART, of the University of Iowa, gave the address at the recent dedication of Wakefield Science Hall at Park College, Parkville, Mo.

DR. E. R. LE COUNT, professor of pathology at the Rush Medical College, Chicago, delivered the annual lectures in pathology under the auspices of the department of pathology of the University of Oregon Medical School, on May 25, 26 and 27, on "The kidney and its inflammations." On May 28 Dr. Le Count addressed the Portland Academy of Medicine on "Some evidences of pathological bone formation."

THE Sigma Xi Alumni Club, of the University of Pittsburgh, held a meeting on June 1 when the following program was presented: "Solar wave lengths," by Dr. Keivin Burns; "The Allegheny Observatory variable star program, methods and progress," by Dr. Frank C. Jordon, and "Solar eclipse problems," by Dr. Heber D. Curtis.

DR. HERMAN FREUNDLICH, of the Kaiser Wilhelm Institute, Germany, addressed the regular meeting of the Chicago section of the American Chemical Society on June 12 on the subject of the "Importance of colloid chemistry in technical practice."

PROFESSOR KURT KOFFKA, of the University of Giessen, who has been visiting professor of psychology at Cornell University this year, will this summer lecture on psychology at the University of Chicago.

A MEMORIAL to Ernest De Witt Burton, president of the University of Chicago, who died recently, will be established by seniors of the graduating class. The memorial will take the form of an honorary professorship. The interest from $30,000 will be given each year to some professor for meritorious or noteworthy work.

THE Council of the League of Nations has adopted a resolution of regret at the death in an automobile accident near Beirut, Syria, on May 22, of Dr. Samuel T. Darling, of Baltimore, Md., corresponding member of the league's commission on malaria and a member of the staff of the Rockefeller Foundation.

A MEMORIAL has been planned by a committee of physicians and naturalists in the form of a fund of $100,000 to the memory of Ernest Harold Baynes, who died recently in New Hampshire. As much of the income from the fund as may be necessary in the discretion of the committee will be paid to the widow, and the remainder, and, at her death, the principal, will go to the American Association for Medical Progress which Mr. Baynes helped to organize. Dr. W. W. Keen, Philadelphia, is chairman of the committee, and among other members are Drs. William H. Welch, Baltimore, Md.; William J. Mayo, Rochester, Minn.; Frank Billings, Chicago; Ray Lyman Wilbur, Leland Stanford University, Calif., and Harvey Cushing, Boston.

DR. MANSFIELD MERRIMAN, professor of civil engineering at Lehigh University from 1878 to 1907 and a pioneer in the development of technical education in the United States, died on June 6 at the age of seventy-seven years.

DONALDSON DOWLING, geologist and explorer, who was connected with the Canadian Geological Survey for thirty years, has died at the age of sixty-seven years.

SIR W. F. BARRETT, F.R.S., formerly professor of physics at Dublin University, known for his work on the electric and magnetic properties of alloys, has died at the age of eighty-one years.

DR. A. G. BUTLER, well known as an entomologist and ornithologist and a former official of the British Museum, died on May 28 at the age of eighty years.

THE death is announced of Dr. Antoine de Page, distinguished Belgian surgeon.

WE learn from *Nature* of the death of Professor Gugliemo Körner, professor of chemistry in the Royal School of Agriculture in Milan, and of Dr. Barthold Hansteen Cranner, professor of botany at the Agricultural College at Aas, Norway.

THE annual meeting of the French Association for the Advancement of Science will be held at Grenoble from July 17 to August 9.

THE thirty-third annual meeting of the Society for the Promotion of Engineering Education was held from June 16 to 20 at Union College, Schenectady, N. Y. An inspection of the plants of the General Electric Company and of the American Locomotive Company was made on June 16.

THE second of the triennial chemical conferences

under the Ernest Solvay Trust was held in Brussels, on April 16–24. As we learn from *Nature* the members of the Scientific Committee present were: Mm. E. Briner (Geneva), O. Dony-Henault (Brussels), J. Duclaux (Paris), F. M. Jaeger (Groningen), A. Job (Paris), J. Perrin (Paris), F. Swarts (Ghent). In addition, the following attended by invitation: H. E. Armstrong (London), E. F. Armstrong (Warrington), G. Barger (Edinburgh), W. Barlow (London), A. Berthoud (Neuchatel), J. Boeseken (Delft), W. L. Bragg (Manchester), C. S. Gibson (London), Sir W. B. Hardy (Cambridge), T. M. Lowry (Cambridge), Ch. Maugin (Paris), Ch. Moureu (Paris), E. K. Rideal (Cambridge), H. Staudinger (Zurich), H. von Euler (Stockholm). The following professors in the University of Brussels were also present: G. Chavanne, J. Timmermans, H. Wuyts, E. Saerens, E. Herzen.

THE *British Medical Journal* states that the International Conference for the Use of Esperanto in Pure and Applied Science, which was held in Paris from May 14 to 16, was attended by delegates of 112 societies. M. Agourtine, of Paris, reported on the progress made since the first meeting of Esperanto doctors held in Cambridge, and the formation of a medical association (known as "Teka") in 1908. The activity of this association, suspended during the war, was revived in 1922, and considerable interest had been shown by many medical practitioners, especially in Japan. Another report on Esperanto and pharmacy related the progress of the International Pharmacopoeia proposed in 1910, the associated federation being established in 1912. It was reported that the difficulties in establishing an international nomenclature were being gradually overcome.

TWO scholarships will be awarded this year by the Chemists Club of New York to students in industrial chemistry and chemical engineering, it is announced by the American Chemical Society. One is the Bloede scholarship, with an income of $500, founded by Dr. Victor G. Bloede, of Baltimore, and the Hoffmann scholarship, with an income of $400, endowed by William H. Hoffmann, of Newark.

DR. WILLIAM SCHAUS, of the National Museum, sailed for France on June 4 to bring the Dognin collection of moths to Washington. Dr. Schaus, who is accompanied by Dr. J. T. Barnes, of the division of entomology, raised $50,000 by private subscription to purchase the 82,000 specimens in the collection.

THE new Peabody Museum, of Yale University, which was opened to graduates of the university during commencement week, will be open to the general public in October.

THE Rowett Institute of Research in Animal Nutrition, Aberdeen, has received from Duthrie Webster, a cattle breeder of Tarves, Scotland, a sum of money for a permanent endowment for the maintenance of an experimental stock farm to be carried on in connection with the institute.

OWING to the consolidation in Geneva of the De Candolle Herbarium, established by Augustin Pierre de Candolle, the Boissur Herbarium, founded by Pierre Edmond Boissur, and the Botanical Observatory of the City of Geneva, based upon the great private collections of Baron Benjamin De Lassert, the New York Botanical Garden has secured by purchase a large library of books on the classification of flowering plants.

THE paintings of American wild flowers by Mrs. Charles D. Walcott, together with colored plates reproduced from them, were exhibited in connection with the eleventh annual spring inspection of the Brooklyn Botanic Garden on the afternoon of May 12. Over 800 persons attended the inspection. The exhibits of living plants included many varieties of Darwin and Cottage tulips raised from American grown bulbs and presented to the Brooklyn Botanic Garden by the Seabrook Company, of Bridgeton, N. J. There were nearly 10,000 bulbs in bloom.

THE new research institute of the Lankenau Hospital, Philadelphia, a gift from Rodman Wanamaker, has been placed in operation. Ten rooms have been equipped with separate accommodations for bacteriology, physiology, pathology and serology, and one floor to accommodate animals. Dr. Stanley P. Reimann is director of the institute. Eighteen specialists will comprise the staff.

AN experiment station for the study of wild animals, especially monkeys, has been established by the Pasteur Institute, with the support of the French government, in the west African jungle at Kinda, French Guinèa.

THE German Navy has sent out a two-year oceanographical expedition in the *Meteor* to the South Sea, to determine the ocean currents from twenty degrees north latitude up to the border of the Antarctic ice fields. The *Meteor* was rebuilt for the trip, and the government gave the officers and crew a special course of instruction to equip them for the work.

THE *Journal* of the American Medical Association states that an award of $5,000 has been offered by the *Journal of Abnormal and Social Psychology* to any person claiming to produce supernormal, material phenomena, who will be the first to demonstrate the actuality of the same under rigid laboratory conditions. The conditions are that the medium freely, voluntarily and wholeheartedly cooperate with the com-

mittee, that the phenomena be *bona fide,* supernormal and due to some force not previously known to science (they shall not be due to conscious or subconscious behavior of the medium), and that the phenomena be subject to instrumental control, visible and produced in full light. All communications should be addressed to Dr. S. Burt Wolbach, professor of pathologic anatomy, Harvard Medical School, Boston, secretary to the committee, before November 1. The following have consented to serve on the committee: Harlow Shapley, Ph.D., director of the Harvard College Observatory; Theodore Lyman, Ph.D., director of the Jefferson Physical Laboratory, Harvard University; Dr. Walter B. Cannon, professor of physiology, Harvard University Medical School; Carroll C. Pratt, Ph.D., instructor in psychology, Harvard University, and Mr. Harry Houdini.

AT the meeting of the American Medical Association in Atlantic City, the following resolution, introduced by Dr. Horace M. Brown, of Milwaukee, in favor of the study of evolution was passed by the house of delegates:

WHEREAS, Legislatures in several states have enacted legislation relative to the teaching of scientific theories and facts in the educational institutions, and

WHEREAS, Legal procedure is now in process in the State of Tennessee to determine the right of the legislative body thus to inhibit the dissemination of scientific knowledge, and

WHEREAS, A study of the development of mankind ethnologically, embryologically and anthropologically is fundamental to the proper comprehension of scientific medicine; therefore, be it

*Resolved* by the House of Delegates of the American Medical Association, that any restrictions of the proper study of scientific fact in regularly established scientific institutions be considered inimical to the progress of science and to the public welfare.

THE Mellon Institute of Industrial Research of the University of Pittsburgh has issued the Third Supplement to the institutional *Bibliographic Bulletin No. 1* and announces that copies of the publication are sent gratis to all interested persons. According to this supplement, 1 book, 9 bulletins, 35 research reports and 95 other scientific and technical papers were published during the calendar year 1924 by the institutional membership; 12 United States patents were also issued to industrial fellowship incumbents. The total contributions to literature for the thirteen years ended January 1, 1925, have been as follows: 12 books, 36 bulletins, 340 research reports, 509 other articles, and 260 United States patents. Among the noteworthy publications during 1924 were treatises on laundering, acetone and ventilators, and journal contributions on the food value of gelatin, utility of tile and of carbon dioxide, heat insulation, smoke abatement, refractories, coal carbonization, and prevention of corrosion.

ACCORDING to information received by the *Journal of Terrestrial Magnetism* from Professor Saeland, of the University of Christiania, a complete magnetic survey of Norway is at present in preparation under the auspices of the Norwegian Geophysical Commission, and if the necessary funds are made available, it is hoped that the work may be completed in five to ten years. It is also stated that according to information received from Dr. Richard Zimmerman, dated February 17, 1925, the requisite buildings for magnetic and atmospheric-electric work at the Tashkent Observatory are at present in process of erection. The photographic and absolute instruments for both classes of observations have been received from the Central Physical Observatory at Leningrad.

RESOLUTIONS calling for closer cooperation between the federal government and the states in water-development schemes and urging on the Congress the need to appropriate at least $500,000 annually to aid the Water Resources Branch of the Federal Geological Survey were adopted at the meeting of the administrative board of the American Engineering Council held on May 8 and 9 at the Engineers' Club, Philadelphia.

## UNIVERSITY AND EDUCATIONAL NOTES

AN additional gift of $2,000,000 has been given by James B. Duke to Duke University, formerly Trinity College. The gift increases the building fund previously created by Mr. Duke to $8,000,000.

KIRTLEY F. MATHER, associate professor of physiography at Harvard University, has been appointed chairman of the department of geology and geography. Professor R. A. Daly, for many years chairman of that department, is relinquishing his administrative duties in order that he may devote his entire time to research. Professor Mather is spending the summer making geological investigations in Nova Scotia and New Brunswick.

DR. PAUL D. LAMSON, associate professor of pharmacology in the Johns Hopkins Medical School, has been appointed professor of pharmacology in Vanderbilt University School of Medicine.

DR. W. W. CORT, associate professor of helminthology, in the department of medical zoology of the School of Hygiene and Public Health of Johns Hopkins University, has been promoted to a professorship of helminthology. Dr. Norman R. Stoll has been appointed associate in the same department.

PROFESSOR LOREN C. PETRY, professor of botany at Syracuse University, who was on leave of absence last year from Syracuse to teach botany at Cornell University, has accepted a permanent professorship in the latter university.

DR. THOMAS G. PHILLIPS, professor of agricultural chemistry at the Ohio State University, has been appointed professor of agricultural chemistry and chemist of the experiment station at the University of New Hampshire.

DR. MARGARET M. HOSKINS has resigned her position as professor of anatomy at the Arkansas University Medical School to accept an appointment at the University and Bellevue Medical College, New York.

DR. WILLIAM KEILLER, dean of the University of Texas Medical Department, has tendered his resignation but will remain in office for another year. Dr. Charles T. Stone, associate professor of clinical medicine, has been appointed professor of medicine to succeed Dr. Marvin L. Graves.

## DISCUSSION AND CORRESPONDENCE

### BACTERIAL CATALASE

IN a special article published in your issue of November 21, 1924, entitled "Enzymes of thermal algae," Professor R. B. Harvey draws attention to the absence of the ferment catalase in the alga Phormidium Laminosum, found in hot springs. The interest of this finding is undoubted, but it is not unique as the author appears to suppose, since he states "this is the first instance of its (catalase) absence from an organism having been demonstrated." Professor Harvey has apparently overlooked the literature on bacterial catalase, which although it is not very abundant has been slowly accumulating for the last twenty-two years.

Observations on bacterial catalase appear to have been first made in the year 1893 by Gottstein[1] and Beyerinck,[2] and from the onset Beyerinck pointed out the important differentiation afforded by testing bacteria for catalase activity, since lactic acid bacteria lacked it.

Löwenstein[3] was apparently the first to demonstrate the absence of catalase in an anaerobe ten years later. Orla-Jensen 1919[4] again drew attention very particularly to the absence of catalase in lactic acid bacteria. In 1923 McLeod and Gordon[5] suggested a bacterial classification based on the $H_2O_2$ forming capacities and catalase production of bacteria. Four classes of bacteria were suggested: No. 1, the anaerobes devoid of catalase and very sensitive to $H_2O_2$; No. 2, the lactic acid bacteria, capable of producing traces or small amounts of $H_2O_2$ in their cultures and relatively insensitive to that substance also devoid of catalase; No. 3, a few bacteria such as Shiga dysentery bacilli, devoid of catalase but not tending to form peroxide No. 4, the majority of faculative anaerobes and strict aerobes equipped with catalase in the same way that most other cells are.

Kluyver[6] suggests that the bacteria devoid of catalase are those which obtain energy and food entirely by cleavage of proteins and carbohydrates and which do not utilize oxygen.

JAMES WALTER MCLEOD

MEDICAL SCHOOL,
LEEDS, ENGLAND

[1] Gottstein, *Virchow's Archiv*, 133, 1893, p. 295.

[2] Beyerinck (*Naturwissenschaftliche Rundschau* 8, 1893, p. 671) quoted by Kluyver, see below.

[3] Löwenstein, *Wiener klin. Wochs*, 16, 1903, p. 1393.

[4] Orla-Jensen, "The lactic acid bacteria, etc.," Memoires de l'Academie Roy. d. Sciences et d. Lettres de Danemark, 8me serie, 1919, v. 184.

[5] McLeod and Gordon, *Journal of Path. and Bact.*, 26, 1923, p. 326.

[6] Kluyver, *Zeits. f. Physiol. Chem.*, 138, 1924, p. 100.

### THE REFORM OF THE CALENDAR

IN SCIENCE for March 13 (61, 286, 1925), Professor A. L. Candy writes on the reform of the calendar, the burden of his article being that a calendar of 13 months of 4 weeks each is less desirable than one of 4 quarters of 91 days, 3 months each.

Calendar reformers have for many years been dividing the 52 weeks of the year into 13 times 4 in two ways, 13 months of 4 weeks each, or 4 quarters of 13 weeks each. The first proposal, being the more radical, has naturally received more newspaper advertising in this country; but because of the enormous number of transactions in every-day life on a quarterly or semi-annual basis, the second has probably received more serious consideration in scientific circles. For instance, back in 1884 a prize of 5,000 francs was offered for the best plan of calendar reform, the competition being under French supervision. First and second prizes were awarded for calendars of 4 quarters, each quarter consisting of three months of lengths 31, 30 and 30 days; as Professor Candy proposes.

The simplest proposal for reforming the calendar is that we take one day from each of the months, March, May and August, and add two days to February and one to April. Further, in leap years the extra day should not be added to February, which comes in the middle of a quarter, but to June. That is, in ordinary years, June would have 30 days, and in leap years 31 days. This simple adjustment would make the quar-

ters exactly alike, except that the last quarter would contain an extra day, December 31, and in leap years the second quarter would also contain an extra day, June 31.

It has been pointed out[1] that this would make possible many of the advantages of a perpetual calendar. Many of the troubles we now have with engagements on the first Monday of the month or the third Wednesday of a particular month could be eliminated.

The real enthusiasts, however, are not content with this, but want a perpetual calendar, a given day of the month always falling on the same day of the week. The undoubted advantages of such a permanency are many, but unfortunately ordinary years contain one extra day over the 52 weeks, and leap years contain two, which must be disposed of. If they can be eliminated the calendar becomes extremely simple. In the 13 months' proposal it is only necessary to remember a single month. In the other, the calendar for a quarter must be memorized, but advocates claim that if adopted, a child would have it memorized by the time he is 10 years old.

### THE "NO-WEEK" DAY CALENDAR

The usual suggestion is that certain "no-week" holidays be inserted. This is the suggestion of Professor Candy, and it was the method proposed by the prize winners in the French competition. New Year's Day is a "no-week" holiday between December and January, and in leap years, another "no-week" holiday, which we may term *Leap Day,* must be inserted, usually along with New Year's between December and January, or as Professor Candy suggests in the middle of the year between June and July.

The objection to this proposal is that it interferes with the regular sequence of seven days in the week, which has been undisturbed for hundreds of years. Perhaps these objections are sentimental and religious, rather than scientific, but the fact remains they are very real to a large part of the human race, and must be considered.

### THE INTERCALARY WEEK CALENDAR

To meet this objection and still secure an absolutely perpetual calendar, the Intercalary Week Calendar has been suggested. Ordinary years would consist of 52 weeks, and leap years of 53 weeks, instead of the years of 365 days and 366 days now in use. As this proposal is not so well known, we will treat it at greater length than the "no-week" day proposal.

Instead of one "no-week" holiday in ordinary years and two in leap years, there would be an extra week, perhaps considered a holiday, every leap year, or about every five years. The length of the year is 52.17746 weeks. Searle and Rigge have proposed the following rule for leap years in weeks: "Years divisible by 5 are leap years unless they are also divisible by 50, and further, the first year divisible by 5 following a century divisible by 400 is to be excepted."

This represents the year in weeks as $52+1/5-1/50-1/400$, or 52.1775 weeks, the error being negligible, a week in some 25,000 years. The obvious objection to this plan is the greater variation in the length of the year. As suggested by Searle and Rigge there would be no leap year between 1995 and 2010, and in that 15 years the seasons would shift more than two weeks with respect to the months. It occurred to me that a different formula might lessen this effect, and after a few trials I found that $52+1/5-1/40+1/400=52.1775$. This formula expressed in words gives the rule: *"Years divisible by 5 are leap years unless also divisible by 40, in which case they are leap years only if divisible by 400."* By this rule, leap years would never be omitted at a closer interval than 40 years and the objectionable shift of the seasons would be lessened. The error in the length of the year is exactly that of the formula of Searle and Rigge, in fact, exactly that of the Gregorian year now in use. For comparison we give the Gregorian rule for leap days: "Years divisible by 4 are leap years unless also divisible by 100, in which case they are leap years only if divisible by 400."

The Intercalary Week Calendar should be considered more seriously by those advocating a perpetual calendar, with a given day of the month always falling on the same day of the week. It offers a simple means of attaining this end without the objectionable "no-week" day. The rule for leap years is simple, and the error in the assumed length of the year is no greater than in the calendar now in use.

The extra week in leap year would give, at the end of some quarter, a month of 37 days about once in 5 years. The variation of 30 to 37 days is little worse than the 28 to 31 occurring regularly in our present calendar, and it would occur only once in 5 years. Thousands of teachers are now employed on a ten-month basis, and have, as far as salary is concerned, a ten-month year, the months varying from 28 to 90 days, or worse.

The real objection is that the use of leap weeks necessitates a variation in the date of the equinox, that is, in the seasons. However, climatic variations from year to year cause a variation of about a month in the time of spring planting and the blossoming of fruit trees. A little additional variation would cause persons engaged in agriculture no great inconvenience, although it would inconvenience the weather bureau and those collecting meteorological statistics. The average person would be affected much less than by the variation we now have of 35 days in the time of Easter.

[1] Philip, "The Reform of the Calendar," page 119.

SUMMARY

Persons who are interested in an immediate reform of the calendar might well confine their efforts to a readjustment of the lengths of the months. A few minor changes would make possible simplifications of benefit to every one.

Those making a study of perpetual calendars, expecting to eventually secure the adoption of one, should consider not only the "no-week" day, but also the "intercalary week."

CHARLES CLAYTON WYLIE

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## THE JONAS VILES, JR., MEMORIAL SCHOLARSHIP

THE department of zoology of the University of Missouri is the recipient of a scholarship which is sufficiently unique to warrant formal record in SCIENCE. Jonas Viles, Jr., a member of the class of 1924 in arts and sciences in this institution, died on July 30, 1924, at the age of nineteen years, after suffering acutely for some weeks from a cancer of the lungs that had been earlier diagnosed as tuberculosis. He had served the department above mentioned as an undergraduate assistant since the middle of his junior year and was majoring there. In the season of 1923–24 he chose the general field of zoological science as his life work and was to have entered the Harvard Medical School in September, 1924, to prepare himself for teaching and investigation in one of the fundamental medical sciences. For the summer of 1924 he had been admitted to the course in invertebrate zoology at the Marine Biological Laboratory, where he was to have occupied one of the places for which the University of Missouri is a subscriber. He was looking forward to this work as the realization of a dream of long standing and as marking the beginning of many such summers. At the time of his death there was a life insurance of one thousand dollars and a substantial sum accumulated from his own earnings, which latter he had planned to spend for his first year of graduate work. During the last weeks of his life he talked constantly of his hopes for the summer and expressed the wish, as he began to sense the hopelessness of his condition, that he had enough to found a scholarship of several hundred dollars to enable students from Missouri to pursue such summer work as he had intended; for he understood the obstacle of traveling expenses that often proves an insurmountable barrier to students from the Middle West who wish to reach either coast.

Because of this desire, expressed by their son as something he wished to see accomplished, his parents, Professor and Mrs. Viles, are setting aside their son's accumulations, plus such other amount as may be necessary to produce an annual income of $100 as the above-mentioned scholarship. By the terms of the gift, this sum is to be used to defray the traveling and other personal expenses of an advanced student during summer work at a suitable institution. Because of the circumstances, the Marine Biological Laboratory at Woods Hole, Massachusetts, will receive special consideration, but the department is free to select another institution that may better suit the needs of the appointee for a given summer. It is not intended that the money derived from this scholarship shall be used to pay for a table or other fees commonly subscribed for by an institution, but rather to place a middle western student upon an equal footing with those for whom the cost of transportation is not a serious burden. The foundation will, we are sure, prove a great incentive in the zoological department at Missouri. It is unique in its origin and in the spirit which led to its establishment, representing as it does a gift to others of what a youth had hoped for himself but was not destined to realize. Jonas Viles, Jr., was a boy of fine intellectual endowment and high ideals, which, taken with his background of cultural training in the home and in the university, would have carried him far in his chosen profession. What would have doubtless proved a brilliant career has ended at its threshold, but he has provided others with the means for an induction into the work he would have made his own.

W. C. CURTIS

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## SCIENTIFIC BOOKS

*Arrowsmith.* By SINCLAIR LEWIS. Harcourt Brace and Company.

IN Arrowsmith Lewis continues to blaze the trail in American literature. Here is a novel of the first rank with a scientist for its main character. This is significant in that it is an added bit of evidence of a certain shift in our civilization shown by the growing interest of the layman in scientific matters. With the coming of this interest, suspicion has given way to support. Some of this attitude is probably due to the discovery that Science will pay dividends, and some is due to the hospitality shown to the layman by Science. The High Priests have taken off their false whiskers and have given Mr. Average Citizen a peep at the ceremonies going on inside the Temples.

It required no small amount of courage on the part of Lewis to choose a scientist for his hero and to write of his work, clearly and intelligently, without yielding to the temptation to write down to the technical knowledge of a novel reading public. This

he has done, aided undoubtedly by the realization that there is a certain quality in the courage of an author with two best sellers to his credit that is not strained by such an innovation.

Arrowsmith is the tale of a young so-called Anglo-Saxon, born in the State of Winnemac, which is bounded by Michigan, Ohio, Illinois and Indiana. He gets his first glimpse of the healing art in the office of a country doctor. He studies medicine at the State University and marries while still a student. After graduation the story carries him through an internship; into the vigorous competition of practice in a small town; thence to the Department of Public Health in Nautilus under Dr. Almus Pickerbaugh, the "two-fisted fightin' poet doc"; to the Rouncefield Clinic as pathologist in a group practice; to the McGurk Institute where he again comes under the influence of his old teacher Gottleib. While here he discovers the bacteriophage and is on the point of being made head of his own department when it is found that D'Hérelle had already made and reported the discovery. In view of this, his department does not develop. Later he is sent to an island in the West Indies to try a plague bacteriophage on the natives who are dying in large numbers from the disease. Here he loses by death his wife Leora and his close friend Sondelius. He returns to the institute, marries a prominent society woman who, curiously enough, bears him a son. He becomes dissatisfied and the book leaves him in a shack in the Vermont hills where he finds peace in his work and the companionship of Terry Wickett, a former worker at the institute.

This brief synopsis fails completely to convey an adequate idea of the richness of the plot or variety of the characters. Gottleib, Pickerbaugh, Holabird, Sondelius, Terry Wickett, Leora . . . any one of them would have filled a novel. In Leora, Lewis has done a fine piece of pioneering. Here is a heroine that is neither a fallen woman struggling up from the depths, nor a wide eyed Polyanna bathed in sweetness and light. She is real and human; full of faults but lovable. One mourns her passing during the plague epidemic. What a tale it would have made, had she married Terry Wickett!

Lewis had as a collaborator Paul H. DeKruif, and much of the verisimilitude of the action and characters is no doubt the result of his efforts. From the charming little verse (somewhat expurgated) about the old German who lived on Olympus, that every medical student chants as a prayer while learning the cranial nerves, to the formula accounting for the action of beta and gamma rays, the story rings true. The scientist and more specifically the medical man, has appeared in literature in the past. The former hid in his laboratory, surrounded by retorts and carried on mysterious reactions with unnamed chemicals. Satirists have shot at the medical man with their delicate barbs, and he has loomed in the background of leaden dramas, chanting a doleful prophecy of the inevitable sequelae of a loose life, torn between the conflicting forces of professional ethics and a high regard for the beautiful heroine. But these characters were always frankly fictional, and other scientists never recognized their counterparts among the members of the profession. In Arrowsmith, medical men will meet all their classmates and some of their teachers in the first eight chapters, and most of their fellow workers in the remaining thirty.

Lewis prefers the thrust of the rapier to the swish of the broadsword and in this he has shown a rare sense of proportion. It is not fitting to use a broadsword on toy balloons. In his agile fencing he touches many raw spots. He lays bare the petty jealousies of the small town practice and the potent effect of small town gossip, either for or against the practicing physician. He shows the inability of the small town mind to dissociate between a man's skill with the scalpel and his belief in the Book of Genesis. He turns a glaring spotlight on public health activities, throwing into bold relief the political machinery that is grinding away behind the scenes. He tells of the supply houses that furnish the go-gettem physician with his Belasco stage settings of scientific machinery, guaranteed to increase his practice enormously, or money back if not satisfied. He thrusts at the commercial organizations who produce serums and vaccines for every ill that human flesh is heir to, and who are not above producing nostrums, provided these are not sold under their label. He exposes the fawning that is indulged in by practically all members of his McGurk Institute, for the sole purpose of currying favor with one's immediate superior. He hints that this institute is prone to rush into print with poorly developed results, merely for the sake of showing that it is producing, even though the product be second rate. He shows the clash between the desire for a scientifically controlled experiment and the humanistic urge to cure or relieve suffering. He paints a touching picture of the war times, with the bewildered scientist trying to act at ease in leather puttees and a Sam Browne belt. There is scarcely a foible of medicine or public health that is not touched on, and none of these is dragged into the narrative by force, but all move in smoothly and logically.

Lewis is skilled in deft caricature and while some of the characters may seem slightly overdrawn, no doubt the originals, when such existed, were let off

with light sentences. The climax of the Health Fair held in the Reverend Billy Sunday's Tabernacle, when the eugenic family proves to be a gang of well-known crooks, and when the fireman sets the place on fire by dropping a lighted match into the Clean Up and Prevent Fires Exhibit . . . certainly this is a purple passage of burlesque. In spite of the intricate pattern of the plot, the rich variety of characters and the wide range of scene, the story has a smooth, unbroken rhythm that maintains its pace throughout. Lewis displays his craftsmanship when he assembles the materials, visits the scene, and then writes a description of a plague epidemic that could only have been written by an eye witness . . . or an artist.

Every intelligent medical man with a sense of humor will enjoy the book. Every medical student who feels vague rumblings of scientific curiosity or the urge for pure research, should read it. All embryo scientists, or even those nearing full term, may turn to it as a sanctuary, because, after all, the flame that burns in Arrowsmith, sometimes bright and sometimes flickering low; the moments of high egotism and the dark moments of doubt; the times of pride in the profession and the times of blushing shame; the bursts of frenzied work in the confidence of the outcome and the long spells of idleness shrouded in despair; the wavering allegiance between Truth and Mammon . . . these are common property. In Main Street, Lewis was the depicter of the American scene. In Babbitt, he was the pathologist at the necropsy table with Mr. Babbitt on the slab. In Arrowsmith, he is an artist.

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## SCIENTIFIC APPARATUS AND LABORATORY METHODS

### HEAVY MINERAL OIL AS A PERMANENT NON-VOLATILE PRESERVATIVE FOR VALUABLE BIOLOGICAL MATERIAL

ANY one engaged in routine curatorial work has no doubt often found, in going over alcoholically preserved material, that the liquid had completely evaporated from defectively corked or infrequently inspected bottles, resulting either in the destruction or serious deterioration of much valuable material. One or two such accidents is all that is necessary to make an otherwise valuable specimen practically worthless. Where adequate curatorial assistance is not available, or where material of this sort is neglected for long periods of time, as is very often the case with small or inactive collections, the aggregate amount of destruction arising from this source alone is sometimes almost total.

Small vials, no matter how well they may appear to be stoppered, are never safe so long as alcohol is used as a preservative. Where type material is concerned this perpetual risk is doubly regrettable.

In consequence of these facts it would appear that a substitute preservative involving none of these objections would be a highly desirable acquisition.

Such a material has been found and tested out sufficiently to merit serious consideration in this connection. The process involved in its utilization is here given. The technique developed applies particularly to the smaller arachnids and insects, but could unquestionably be extended to many other groups.

The specimen is killed and dehydrated in the usual manner by means of 95 per cent. grain alcohol. The specimen should be transferred at least once to clean alcohol from that in which it was killed before taking the next step. After dehydration the specimen is transferred to carbol-xylene (25 per cent. carbolic acid crystals in 75 per cent. xylene). After a sufficient lapse of time, the material is transferred to pure xylene, in order to remove all traces of the carbolic acid which is immiscible in the oil. From this last reagent the specimens are transferred to any one of the highly refined, colorless and highly viscous mineral oils, of which Squibbs and Nujol are typical and well-known examples. In large quantities "Oronite Crystal Oil," as put out by the Standard Oil Company of California, is completely satisfactory for this work and very much cheaper than either of the two medicinal oils above mentioned. This material should cost somewhat less than alcohol, but, of course, the necessary stages requiring the use of xylol would make the total first cost somewhat higher. In the long run, however, the oil should be much more economical, since there would be practically no future necessity of replenishing that lost through evaporation as is always the case with alcohol. Carbol-xylene is used as an economical expedient to obviate the otherwise necessary step of passing material through absolute alcohol.

Specimens preserved in this type of oil retain their original colors much better than in alcohol; there is no danger of desiccation arising from the rapid evaporation of the preserving fluid; the specimens retain much of their original flexibility and consequently can be studied and handled with much less danger of breakage than is the case with alcohol preserved and hardened material; and finally the optical qualities of the oil are practically identical (the refractive index is higher: about 1.47) with those of alcohol, so that no disadvantage is experienced on this score. Specimens thus preserved are practically as free from possible injury or deterioration as balsam mounted, slide

material and infinitely more so than that which is pinned and dried. The only deterioration possible is that arising from breakage of the containing vessels.

There is one point of caution that should be borne in mind concerning these oils. They are absolutely neutral and non-toxic and it is not impossible that improperly treated material might ultimately develop decay. This could not occur, however, with specimens properly sterilized and completely dehydrated in the beginning, since no bacterial action can continue in the absence of both oxygen and water. It is also well to bear in mind that with all material, except that which is usually or just as easily studied while immersed in liquid, difficulty would be experienced in ridding the specimen of surplus oil. This could of course be easily accomplished by washing with xylene.

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## SPECIAL ARTICLES

### ARC SPECTRUM REGULARITIES FOR RUTHENIUM

THE arc spectrum of iron having been investigated by Walters[1] and by Laporte,[2] it appeared desirable to study the corresponding element, ruthenium, of the next period.

According to a plan of cooperation which was arrived at with the Institute for Theoretical Physics of the University of Munich, through the courtesy of Professor A. Sommerfeld, the elements Rh and Pd are being investigated for spectral structure by Drs. Catalán and Bechert, while the Ru analysis has been undertaken by ourselves. We are thankful to Dr. Bechert for his kindness in communicating to us some provisional results in Ru.

Although new wave length measurements[3] have been made by Meggers, no other experimental data (temperature classification and Zeeman effect[4]), which have been so important for the analysis of the iron spectrum, were available. As a substitute for absorption or furnace spectrograms we made photographs of the spectrum emitted by a condensed spark under water which showed 85 distinct absorption lines[5] between 2255 and 4709A. From these we recognize the lowest term of ruthenium as being a 5-fold term with the separations 392.2, 621.7, 900.9, 1190.8 $cm^{-1}$, and the inner quantum numbers 0, 1, 2, 3, 4, which in analogy with iron may be regarded as a quintet-D term. It must be pointed out that many separations which appear to be real (including three of the $\Delta$ D) were found by E. Paulson[6] ten years ago. The D term combines with 46 or more higher levels, thus accounting for the majority of strong lines in the ruthenium arc spectrum. The azimuthal quantum numbers of these levels are indicated by the fact that in general only the main lines and not the satellites of a combination appear in absorption. As an example of the combination of the low D term with a higher F term, we give the following multiplet to which we were guided by the strong occurrence of the main lines and the weak occurrence of the first satellites in absorption. The preliminary wave lengths and intensities here given were derived from an arc spectrogram made for this purpose, since

[1] Walters, Journ. Wash. Acad. Sci., 13, 243; 1923; J. O. S. A. & R. S. I., 8, 245; 1924.

[2] Laporte, Zs. f. Phys. 23, 135; 1924; *ibid.*, 26, 1; 1924.

[3] Meggers, Bur. Stand. Sci. Pap. 20, 20; 1925.

[4] The Zeeman data published by Purvis (Proc. Cambr. Phil. Soc. 13, 344; 1906) are found to be of very little value. New observations are being made in cooperation with Prof. B. E. Moore, of the University of Nebraska.

[5] A paper dealing with the under-water absorption spectra of the six platinum metals is in preparation.

[6] Paulson, Phys. Zs. 16, 81; 1915.

| | $^5D_0$ 392.2 | $^5D_1$ 621.7 | $^5D_3$ 899.6 | $^5D_2$ 1190.8 | $^5D_4$ |
|---|---|---|---|---|---|
| $^5F_1$ | 2392.42(15) | 2370.17(12) | 2335.74(5) | | |
| | 41785.9 | 42178.1 | 42799.8 | | |
| 90.5 | | | | | |
| $^5F_2$ | | 2375.27(15) | 2340.69(15) | 2292.41(8) | |
| | | 42087.6 | 42709.3 | 43608.7 | |
| 193.1 | | | | | |
| $^5F_3$ | | | 2351.34(20) | 2302.60(15) | 2241.10(10) |
| | | | 42516.0 | 43415.8 | 44607.0 |
| 286.0 | | | | | |
| $^5F_4$ | | | | 2317.85(25) | 2255.59(20) |
| | | | | 43130.2 | 44320.6 |
| 468.3 | | | | | |
| $^5F_5$ | | | | | 2279.67(30) |
| | | | | | 43852.3 |

the published values[7] do not cover the range of wave lengths covered by this multiplet.

In agreement with a general rule that the most sensitive lines of a spectrum always involve a quantum jump with $\Delta K = 1$, the *raies ultimes*, 3436.74 and 3498.95A, occur also in a $^5D$–$^5F$ combination.

More details of this investigation will appear in the Journal of the Washington Academy of Sciences.

W. F. MEGGERS
O. LAPORTE

BUREAU OF STANDARDS
MAY 29, 1925

## MANGANESE AS A CURE FOR A CHLOROSIS OF SPINACH*

YELLOW chlorotic foliage and poor growth have been noted in spinach grown for several years on heavily limed soil at the Rhode Island Experiment Station. During the season of 1925, spinach planted on April 3 and grown under low temperature and high moisture conditions began to show chlorosis very soon after the unfolding of the first pair of leaves. Accompanying a very slow growth rate, the first indications of chlorosis were observed in the yellowing of the older leaves which gradually led to a disintegration of the chloroplasts and finally to the appearance of dead transparent areas. Determinations of the soil pH range gave figures from 6.2 to 6.9 and when the lime requirement was determined, the range was from 683 pounds to 233 pounds per acre (modified Jones method).

In an attempt to correct this situation without appreciably changing the soil reaction, solutions of 0.02 per cent. ferrous sulfate, 0.004 per cent. manganous sulfate, 0.08 per cent. ammonium nitrate, 0.1 per cent. potassium sulfate, 0.2 per cent. potassium phosphate, 0.02 per cent. ferric ammonium citrate, 0.02 per cent. citric acid, and manure leachings were sprayed on the rows of chlorotic spinach, 9 liters of solution being added to 30 feet of row. These additions were made on soil which had been treated with a complete chemical fertilizer ration and also moderately manured before the spinach was planted. Of these treatments, the only one which gave any positive or marked result was the manganous sulfate. After a period of four days from treatment, a definite improvement in the color of the leaves could be seen and at the end of a week the change was very marked. The previously afflicted plants developed a bright green color and resumed normal growth. Following this initial result, other spinach plants which were growing under the same range of pH and lime requirement and which had begun to show definite indications of chlorosis were treated with a solution of 8 parts per million. Similar results were obtained as with the weaker treatment, thus confirming the original observations. When harvested a 40 per cent. increase in yield was obtained from the treated plat.

In order to localize more definitely the reacting element, plants were treated with a solution of 5 parts per million of sulfuric acid. This treatment caused no noticeable improvement in the chlorotic plants. From these results there are indications that the active element concerned in the cure of chlorotic plants is manganese.

Other investigators have shown, recently, relationships concerning manganese. Loew and Sawa,[2] McCool[3] and Brenchley[1] used solutions containing 15 and more parts per million of manganese salts and obtained chlorosis (in solution culture), which condition was followed by a definite toxic effect. Other investigators, working with concentrations below 10 parts per million, have obtained definite growth stimulation. McHargue,[4] Brenchley[1] and Skinner and Sullivan[6] observed in this connection a correlation between the soil reaction and this stimulatory effect; the less the acidity, the more marked was the growth response to manganese applications. Finally McHargue[5] obtained chlorosis of spinach in sand cultures from which manganese had been very carefully excluded. To the best of our knowledge, however, no one has reported the correction under practical conditions of a chlorotic disturbance of spinach by the use of manganese salts.

The results obtained wtih manganous sulfate as a cure for chlorotic spinach serve to corroborate the observations of other workers and at the same time seem to point to the use of manganese salts in field

[7] Kayser, Handbuch der Spektroscopie VI, 371.

* Contribution 320 of the Rhode Island Agricultural Experiment Station, Kingston, R. I.

[1] Brenchley, Miss W. E., "Effect of manganese compounds." In "Inorganic Plant Poisons and Stimulants," p. 78–92, 1914.

[2] Loew, O., and Sawa, S., "On the action of manganese compounds on plants," Tokyo Imp. Univ., Coll. Agr. Bul. 5: 161–172, 1902–03.

[3] McCool, M. M., "The action of certain nutrient and non-nutrient bases on plant growth," Cornell Univ., Agr. Exp. Sta. Memoir 2: 113–116, 1913.

[4] McHargue, J. S., "Effect of different concentrations of manganese sulfate on the growth of plants in acid and neutral soils and the necessity of manganese as a plant nutrient," Jour. Agr. Research, XXIV: 781–793, 1923.

[5] McHargue, J. S., "Rôle of manganese in plants," Jour. Amer. Chem. Soc., 44: 1592–1598, 1922.

[6] Skinner, J. J., and Sullivan, M. X., "The action of manganese in soils," U. S. Dept. Agr. Bul. 42: 1–32, 1914.

work. Studies of soil conditions and plant reactions are being carried on in the endeavor to interpret more fully this phenomenon.

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## THE AMERICAN CHEMICAL SOCIETY[1]

### PHYSICAL AND INORGANIC CHEMISTRY

Arthur E. Hill, *Chairman*
George Shannon Forbes, *Secretary*

*The application of the Lewis-Langmuir structure of the atom to the theory of coordination:* C. J. BROCKMAN. In building up his theory of complex compounds Werner postulated the existence of a "coordination number" for certain elements, the theory being more or less at variance with the accepted ideas concerning valence, etc. Now it is suggested that the formation of complex compounds be due to an inherent desire on the part of certain elements to complete its outer shell of electrons to that configuration which is characteristic of the next higher inert gas, by taking on single or pairs of electrons from ions in solution or from molecules, etc., as they are available for such absorption. When electrons in such ions are absorbed by the central element the union between coordinated atoms or radicals becomes noniogenic. In support of this theory complexes containing Pt, Cr, Co and Fe as the central atoms have been studied.

*The electric moments of the molecules of monocarboxylic acids and their esters:* CHARLES P. SMYTH. The electric moments of the molecules of a number of monocarboxylic acids and esters are calculated from their structures, which are assumed to be formed by the linking of atoms by electron pairs symmetrically located at the apices of regular tetrahedra. The ratio of the moments thus obtained to those previously calculated in a similar manner for the molecules of the ketones, aldehydes and alcohols is in good agreement with that of the moments obtained from experimental data on these substances. The principal moments of the molecules induce secondary moments on the carbon chains of the esters, but, in conformity with the structures indicated by the X-ray measurements of Müller and Shearer, these induced moments oppose and nearly cancel one another in the carbon chain of the acyl radical of the ester, but reenforce one another in the chain of the alcohol radical, so that the moment of the molecule as a whole increases with increasing length of this chain, but changes little with increasing length of the acyl chain. The fact that the variations among the electric moments of different molecules may be explained by the assumption of electrons pairs shared between atoms which tend strongly to maintain their effective positions in definite symmetrical locations in the molecules seems to support the idea that valence forces are highly localized and directive in character, as indicated by the X-ray study of solids and the recent conclusions of Vorländer upon liquid crystals.

*Adsorption and Schulze's law:* HARRY B. WEISER. Schulze's law, that the precipitating power of an electrolyte is greater the higher the valence of the precipitating ion, is but little more than a qualitative rule. In so far as the rule holds, the adsorbability of an ion is greater the higher the valence. The conclusion of Dhar and his collaborators that ions with the lowest precipitating power are adsorbed the most and *vice versa* is both theoretically and experimentally unsound. An indirect method has been devised for determining the relative adsorbability of weakly adsorbed univalent ions. With strong electrolytes containing weakly adsorbed precipitating ions and the same stabilizing ion there is a direct relation between the relative adsorbability of the precipitating ions and the coagulating power of the electrolytes in the sense that the electrolyte containing the most readily adsorbed precipitating ion coagulates a sol in lowest concentration.

*Mechanism of the photochemical reaction between hydrogen and chlorine:* A. L. MARSHALL. An investigation has been made of the reaction between atomic hydrogen and a mixture of hydrogen and chlorine at low pressures. It has been found that below 0.001 cm pressure there is a yield of one molecule of hydrogen chloride per atom of hydrogen, while at 0.60 cm pressure the yield is ten molecules per atom of hydrogen. An explanation of these results can be found assuming the reactive form of chlorine to be an energy-rich chlorine molecule. It can be shown from kinetic theory considerations that at pressures below 0.01 cm the mean free time between impacts is longer than the average life of excited chlorine molecules which is taken as of the order of (10) −6 secs. Hence a yield of one molecule of hydrogen chloride per atom of hydrogen is to be expected. At higher pressures where the kinetic mean free time is shorter than this the yield per atom should increase. The mechanism postulated for the reaction is

$$H + Cl_2 = HCl\ (\text{active}) + Cl$$
$$HCl\ (\text{active}) + Cl_2 = Cl_2\ (\text{active}) + HCl$$
$$Cl_2\ (\text{active}) + H_2 = 2\ HCl\ (\text{active})$$

On the basis of this mechanism an explanation is given for the effect of water vapor in the photochemical reaction between hydrogen and chlorine. The primary action of light in this reaction is assumed to be the production of energy-rich chlorine molecules and not atomic chlorine.

*Primary and secondary valence. An attempt to improve the classification of valence:* ARTHUR A. BLANCHARD. Valence is classified in terms of the nuclear atom with the aid of certain general postulates concerning the extra nuclear electrons. Polar valence is the algebraic charge. Non-polar valence in the number of pairs of electrons held in common in the sheath of the atom

[1] Baltimore meeting, April, 1925.

in question and other atoms. Submerged polar valence is the net charge of an atom if the electrons held in common are credited wholly either to that atom or the other atoms according as to which is supposed to have the greater affinity for them. The maximum number of electrons possible in the successive layers or levels is 2. 8. 18. 32. . . . These numbers give stable layers, but the number rises with difficulty above 8 unless there is an accumulation in an outer layer. The number in the sheath rises above eight only in exceptional cases when the atom is surrounded by other atoms and the electrons of the sheath are all shared, *e.g.*, in the ammoniates and the carbonyls. In general, to completely classify valence, both the polar (or submerged polar) and the non-polar valence and the kernel charge and the number of electrons in the sheath must be given. No line of demarcation between primary and secondary valence can be found, but it is believed that the valence of each atom in all compounds with determinable molecular weight can be classified if we will admit that in exceptional cases single electrons and triplets and even quintuplets can be held in common in the sheaths of two atoms.

*The preparation of hydrogen electrodes:* GERHARD DIETRICHSON and C. N. SHAH. An extensive study was first made of the various methods described in the literature for the preparation of hydrogen electrodes. The difficulties encountered in connection with each of these were carefully noted. Following this the necessary conditions for the electrodeposition of platinum from solutions of pure chloroplatinic acid were determined. This involved in particular a proper control of the concentration and the current density relations. The character of the base on which the platinum was deposited was also found to be important. Hydrogen electrodes prepared by this method were found to give on the whole very satisfactory results.

*Diurnal bands of platinum and stability of gold and platinum oxalates in silica gels:* EARL C. H. DAVIES. (1) Diurnal bands of colloidal platinum have been made by diffusion, in periodic light, of oxalates into an acid silica gel containing platinic chloride. (2) Laboratory directions are given for making silica gels containing oxalates and either platinum or gold chloride with no red or blue gold or black platinum appearing, except by exposure to light. (3) Conditions are described for producing, alternately, red and blue bands of any desired width and at any distance apart, without having any diffusion of oxalates into the silica gel. (4) A photochemical after-effect is found in the reduction of gold oxalate in a silica gel. (5) A study has been made of the effect of aging on the reduction, in dark and in light, of gold oxalate in silica gels.

*Further studies in luminescent Grignard compounds:* W. V. EVANS and EDW. DIEPENHORST. Twenty new luminescent Grignard compounds are reported. The observation is made that apparently all Grignard compounds give luminescence on oxidation if the group combined to the magnesium is heavier than an ethyl group. The luminescence from the aliphatic compounds, however, is as a rule not as brilliant as from the aromatic. Luminescent Grignards have been made in fourteen different solvents and the effect of these solvents on the luminescence noted. A method for making Grignards in sealed tubes is suggested. The para-position is much the best position for producing this light and its intensity increases with the weight of the organic radical in the para-position. The spectrograms of four new compounds have been secured and the observation made that the spectra of the different compounds seem to occupy the same position on the plate, that is, between 447 μμ and 518 μμ.

*The constricted arc as a light source for photochemical work:* GEORGE SHANNON FORBES and GEORGE R. HARRISON. The intensity, steadiness, economy, convenience, efficiency and life of the constricted column mercury vapor lamp are discussed in comparison and contrast with the standard sealed-electrode commercial lamp 8 mm in diameter. The best electrical and cooling conditions for emphasizing each of these factors are given, together with the best conditions for average operation. By absolute measurements it is shown that the constricted arc can be made to give about three times the visible and ultraviolet radiation given by the commercial arc per square millimeter of slit with the same power input, and that from ten to thirty times as much light can be obtained by making a sacrifice in the life of the lamp, which is largely offset by the ease and cheapness of renewal.

*Studies in photographic sensitivity. VII. The action of hydrogen peroxide on single-layer silver halide plates:* E. P. WIGHTMAN, A. P. H. TRIVELLI and S. E. SHEPPARD. Single-grain-layer silver halide plates are only very slightly affected by hydrogen peroxide, no matter what the concentration of $H_2O_2$ or time of treatment, unless they have been given a previous light exposure. In this case the number of grains showing developability seems to be greater than the sum of those produced by light and hydrogen peroxide separately. The reason suggested for this is that not only developable latent image but also undevelopable image is produced by light and that the hydrogen peroxide carries this over into developable latent image as well as makes its own proportion of grains developable. It is shown that Clark's hypotheses (a) that the so-called sensitivity of specks consists of silver oxide or hydroxide (b) that the action of hydrogen peroxide is a purely chemical one on this oxide or hydroxide, reducing this to silver which then makes the plate developable, and (c) that reversal is due to peptization of the silver by the hydrogen peroxide, are all untenable, not being supported by experimental facts. It is further shown that while our original hypothesis that the action of $H_2O_2$ is one of chemiluminescence is not completely substantiated it is at least not strongly controverted except by one fact, namely, that acid $H_2O_2$ seems to be slightly more effective than alkaline $H_2O_2$ in producing a latent image.

On the other hand, alkaline $H_2O_2$ may cause peptization of the sensitivity specks and hence work against the formation of developable centers.

*The effect of solvents on the absorption spectrum of a simple dye:* WALLACE R. BRODE. The absorption spectrum of benzeneazophenol dissolved in thirty organic solvents and in mixtures of some of them was measured in the visible and ultra-violet. No definite relation was found between the frequency of the absorption bands and either the refractive indices or the dielectric constants of the solvents, except for solvents of the same homologous series. When dissolved in a mixture of two solvents, the absorption band is that given by the dye dissolved in the most polar solvent even if only 1 per cent. of this solvent is present in the mixture. The absorption limits of the solvents for a layer 1 cm thick were measured and form a gradual series of radiation filters between a frequency of 850 and 1,350.

*The cathodic deposition of metals:* K. FRÖLICH and GEO. L. CLARK. *I. Theory of the mechanism:* 1. There is no evidence of an intermediate state in the electrodeposition of metals. The discharge of a metallic cation and the subsequent crystallization of the atom thus liberated are two phenomena so intimately connected that they must be considered one process. (2) In the deposition of the metals of the iron group a resistance has to be overcome which can not be traced back to specific properties of the electrolyte. A closer examination shows that the same type of resistance is encountered in the deposition of most metals and gives rise to what is termed the "true metal overvoltage." (3) The true metal overvoltage is highest for metals giving low hydrogen overvoltage and *vice versa*. By discussing this phenomenon in view of the hydride theory of hydrogen overvoltage, the conclusion is arrived at that the true metal overvoltage is caused by the interference of hydrogen with the process of building up the normal space lattice of the metal, while the discharge reaction itself is a reversible reaction for all metals. (4) The relation between metal overvoltage and hydrogen overvoltage appears to be very helpful in explaining the cathodic crystal formation of the individual metals.

*II. A preliminary experimental X-ray study of electrodeposited nickel:* (1) Thirty Laue, monochromatic pinhole and powder diffraction photographs have been taken of nickel films electrodeposited on platinum and on aluminum, the films being split off in the latter case. These specimens were deposited from chloride, sulfate, sulfate containing gelatine, complex oxalate and complex ammonium electrolytes. With the sulfate electrolyte the anode metal, temperature, concentration and current density were varied. (2) The structure of the platinum foil is derived from the well-defined figures characteristic of a strongly rolled metal. (3) The metal deposits of nickel all show the tendency of the crystals to orient themselves with the 100 planes parallel to the electrode surface, though under a condition of strain. Powder diffraction spectra characteristic of random orientation were obtained only with the high temperature electrolyte. With current densities as low as 0.10 amps./cm² the orientation is maintained. Complex ammonia electrolytes give best orientation which must be connected with the vigorous hydrogen evolution and hydride formation. Other deposits are compared. A deposit from sulfate electrolyte split from an aluminum electrode produced a single broad diffraction ring with Mo K alpha rays, thus indicating the extremely small size of the crystals. (4) Copper deposited on platinum at high current densities shows orientation of crystals contrary to other work. (5) The experimental results are interpreted to support in general the theory of the mechanism of electrodeposition presented in the first paper of this series.

*On the photochemistry of fluorescent dyes:* PHILIP SUBKOW. It is shown that the action of light on the solutions of the alkali salts of eosin and fluorescein causes a photochemical reaction to accompany the fluorescence such that the alkali salt is hydrolized and a colloidal solution of the acid dye is formed. Accompanying this reaction is a photochemical precipitation of the colloid. Ozone or certain oxides in the presence of light apparently aid this reaction. That this reaction does not seem to obey the Einstein photochemical law or the Bunsen-Roscoe law in Wood's experiments is explained by the absorptive effect of the colloidal dye on the incident radiation and effects of convective currents. Further, the so-called protective action is explained as due to the absorption of light by the colloid formed by the temperature hydrolysis of the salt.

*Note on the radiation theory of chemical reactions:* PHILIP SUBKOW. Applying the Gibbs equation to Baly's theory of stationary states and phase quanta, it is shown that the absorption regions of $N_2O_5$ as calculated from the velocity of decomposition of $N_2O_5$ corresponds to those actually observed.

*The versatility of ferrous hydroxide:* PETER FIREMAN. Freshly precipitated ferrous hydroxide, in undergoing oxidation through the action of the air, gives rise to the formation of a long series of well-defined colored pigments, in dependence on slight changes in the composition and conditions of the mother liquor. Black ferro-ferric oxide, yellows of the composition $Fe_2O_3 . H_2O$ and browns of the composition $Fe_2O_3$ are briefly described and the broad conclusion is drawn that the oxidation at low temperatures leads to the formation of hydrated oxides of iron yellow in color while the oxidation at higher temperatures leads to the formation of anhydrous oxides of iron.

*The catalytic synthesis of water vapor in presence of metallic nickel:* ARTHUR F. BENTON and PAUL H. EMMETT. A study of the catalytic combination of hydrogen and oxygen over metallic nickel has shown that the water formation is accompanied by superficial oxidation of the catalyst. When the surface has become completely covered with oxide the rate of catalysis suddenly decreases to a small value. The reduction of such

a completely oxidized surface by pure hydrogen exhibits autocatalysis, but even the maximum reduction rates so obtained are small in comparison with the rates of hydro-oxygen combination at the same temperature. The evidence indicates, however, that the interface area, on which the rate of reduction depends, is much greater in the catalytic process than in the reduction. The conclusion is reached that the catalysis can be largely and perhaps entirely accounted for on the theory of successive oxidation and reduction of the catalyst.

*The preparation of phosgene-salts:* ALBERT F. O. GERMANN and CHARLES RUSSELL TIMPANY. In pursuit of the study of phosgene solutions, the ordinary methods of preparing salts were found to be inadequate in the preparation of phosgene-salts. To carry out these preparations, an apparatus has been devised in which 100 grams of crude salt may be prepared and purified by recrystallization and washing in phosgene solution without contact with the atmosphere, by a reaction in which metallic chlorides are neutralized by a phosgeno-acid, as follows: $CoAl_2Cl_8 + CaCl_2 = CaAl_2Cl_8 + CoCl_2$. A method of analysis of the product, which carries phosgene of crystallization, is given. The vapor tension and solubility of the salt in phosgene at 25° are given.

*A general theory of solvent systems:* ALBERT F. O. GERMANN. Based on the well-known behavior of water and of ammonia solutions, it would seem plausible to expect the typical ions of acids to deviate from the familiar $H^+$ type, just as the typical ion of bases is known to deviate from the $OH^-$ type, when a wide variety of solvents is investigated. The term "parent solvent" is defined, and its relation to a system of related acids, bases and salts outlined. Application of these ideas is made to phosgene, which is shown to yield an acid in which $CO^{++}$ replaces $H^-$ of the familiar acids. Reactions of this acid in phosgene solution parallel the reactions of familiar acids in water solution. Applications to other solvents are suggested.

*Note on some properties of some soluble borates:* F. P. DUNNINGTON. When lithium carbonate in excess is boiled with boracic acid solution, there is formed lithium di-meta-borate. This is very soluble in cold water and may be concentrated to a syrupy consistency, while the corresponding sodium salt, borax, is little soluble. Potassium di-meta-borate, made by mixture of molecular weights of potassium hydrate and boracic acid, is soluble in about four parts of water. Solutions of lithium, sodium and potassium di-meta-borate are alkaline to litmus and to phenol phthalein. If each of these in solution is titrated with boracic acid until neutral to phenol phthalein, it will in each case require exactly one more molecule of boracic acid and so form the tetra-meta-borate. The sodium tetra-meta-borate is soluble in about four parts of water. The stronger water solutions of borates present the antiseptic properties of boracic acid in a more concentrated form than has heretofore been employed in surgery.

*Emulsification:* BRIAN MEAD. Some unusual results have been obtained, using sodium oleate and sodium stearate as emulsifying agents. Sodium oleate can, under certain conditions, be made to give water in oil emulsions by exposure of its solution to air. Sodium stearate, under certain conditions, will dissolve in oil and will then act as an emulsifying agent for water in oil. The significance of these results is discussed.

*The oxidation of benzaldehyde:* BRIAN MEAD and J. D. COCHRANE, JR. Benzaldehyde, which is usually considered to be an example of an autoxidizable substance, has been found not to be so. The amount of oxidation which takes place (as measured by the actual absorption of oxygen) is found to depend entirely on the intensity of the light to which the benzaldehyde is subjected. If the source of light be cut off, when the oxidation is proceeding, the reaction ceases after a very short interval. It will proceed at the same rate if the benzaldehyde is again illuminated. Preliminary results with X-rays shows that these do not cause the reaction to proceed at all.

*The partial molal heat content of ammonia solutions:* GERHARD DIETRICHSON, R. T. LESLIE and J. E. WHITTENBERG. The partial molal heat content of ammonia solutions has been determined at 25° C. over a range of concentrations from 0.1 to 0.7 mol-fraction of ammonia. This was done by means of an adiabatic calorimeter involving a distillation process. The amount of electrical energy required to vaporize definite quantities of water and ammonia from solutions of different concentrations was first determined. The heats of vaporization so obtained were plotted against the corresponding mol-fractions. The partial molal heat contents were in turn obtained by making use of the method of intercepts. The experiments carried out on ammonia solutions represent an attempt to supply some of the thermal data that are needed in connection with the absorption refrigeration process.

*The mechanism of the fixation of nitrogen as sodium cyanide:* E. W. GUERNSEY and M. E. SHERMAN. It has been found that the formation of sodium cyanide in a heated mixture of sodium carbonate, carbon and iron proceeds by the following steps: Sodium carbonate is reduced to give metallic sodium, metallic sodium reacts with carbon to form sodium carbide and sodium carbide absorbs nitrogen to form sodium cyanide, this latter reaction occurring in the gas phase. Each of these steps has been carried out, and it has been shown to be improbable that there is an appreciable amount of cyanide formed except through this series of reactions. Both the formation of sodium carbide from the elements and the absorption of nitrogen by the carbide are distinctly reversible reactions. Iron appears to exert marked catalytic action only on the final reaction, the formation of cyanide from carbide and nitrogen.

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